THE RESISTANCE TO DECOMPOSITION OF CERTAIN ORGANIC MATTERS IN SEWAGE.

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THIS investigation, in regard to the resistance to decomposition of certain organic matters, was begun in order thoroughly to comprehend the conditions prevailing in certain sand filters which had received sewage for periods varying from 10 to 17 years. Studies of the work accomplished by these filters during these many years of operation show that only about 55 per cent, of the nitrogen in the sewage applied to them has appeared in their effluents. Studies of municipal areas, moreover, receiving a fresher sewage, have shown that only about 30 per cent of the applied nitrogen appears in the effluents from these areas. Much of the remaining nitrogen is set free by nitrogen-liberating bacteria; but a small percentage of the nitrogenous matters is resistant to bacterial actions and accumulates within the filter—from 4 to 8 per cent in the experimental filters at Lawrence.[1]

The filters under discussion had stored, in the period stated, enough organic matter seriously to impair their satisfactory operation; that is, the upper layers of these filters had become clogged to such an extent that it was necessary to break through these layers and to ridge and trench the surface of the filters in order that good purification of the applied sewage might be obtained. It was hoped that, by this surface treatment, the sand piled in ridges would lose the larger part of its stored organic matters by the work of the bacteria present, thus given a chance to work over the organic matter stored in the sand, rather than the organic matter in the sewage applied daily.

From the sand of the ridges, arranged in this way upon the three filters chiefly studied, differing amounts of nitrogen disappeared. From the ridges upon two filters constructed of coarse sand, 46 per cent of the stored nitrogen disappeared in three months, and from the ridges upon a filter constructed of comparatively fine sand, only

[1] For a fuller account of this work, see *Report of Massachusetts State Board of Health*, 1904.

about 10 per cent disappeared in an equal period. The residual nitrogenous matters remaining upon the sand in these ridges remained, however, after this first quick and easy removal, month after month without change, during weather favorable to bacterial activity in the filters.

Following this work, small filters of sand, taken from the upper portions of the three sand filters under investigation and rich in organic matter, were constructed. These small filters, started early in May, 1904, were placed in the laboratory and kept under conditions favorable to nitrification. Each of these filters was flooded with water, and the rate of operation of each was 30,000 gallons per acre daily. Nitrification started immediately in the filter constructed of coarse sand, and at the end of a week of operation, the effluent of this filter contained 15 per cent of nitrates per 100,000. In the other two filters, nitrification also started quickly, and the nitrates in the effluent of each became comparatively high very soon after the beginning of their operation. The nitrates remained high for about two months, and much of the nitrogenous organic matter on the sand was removed during this period; from the filter of coarse sand, 70 per cent, and from the remaining filters 55 and 30 per cent, respectively. At the end of this period of quick nitrification, however, although conditions were the same, nitrification practically ceased, and the organic matter upon the sand, both nitrogenous and carbonaceous, remained constant in amount. Determinations of the nitrogen in each filter and in the effluent of each were made, and it was shown that of the total amount of nitrogen removed from the sand of each filter during its period of operation a very varying amount had passed off in the three effluents; in the effluent of one, only 18 per cent of the total amount, in the effluent of the second, 23 per cent, and in the effluent of the third, 71 per cent. That is to say, much nitrogen lost from the sand passed away in the air, as the result of the work of the nitrogen-liberating bacteria undoubtedly present in each filter, the largest amount being liberated from the filter of coarsest sand.

After nitrification had been low in each filter for a period of several months, and the organic matter upon the sand had remained at a practically constant figure, as shown by various analyses, attempts

were made to increase nitrification, by dosing each filter with chemicals or cultures of bacteria, to induce the activity of the nitrifying organisms. Small amounts of sewage were added, also, in order to be sure that nitrifying bacteria were present in each filter, but this was without effect in increasing nitrification. Further, in order to prove that the filters were capable of producing nitrates, if easily nitrified matter was applied to them, a solution of ammonium chloride and sodium carbonate was applied to one filter, and peptone to a second filter. Following the application of these substances, nitrification again became high in each filter, but ceased quickly when these bodies were omitted from the water applied.

In order to study further the character of the matter stored in these filters, determinations of the total organic matter present were made. By this means, it was found that the nitrogen present was a very small and varying per cent of the total organic matter, probably not more than 3 per cent, judging from many analyses, and that the principal clogging matter upon the sand was carbonaceous and of the nature of cellulose. The investigation is still under way, but so far shows clearly that there is in ordinary domestic sewage a certain small percentage of exceedingly stable carbonaceous and nitrogenous matter, that, accumulating year after year, seriously impairs the work of these filters; that these matters are but slowly affected by the ordinary bacterial actions depended upon to oxidize, or cause the disappearance, of organic matter; that even when this clogged sand is taken from the filters and placed under conditions favorable to nitrification, as in the small filters described in this paper, a considerable portion of the organic matter remains unaffected; that the larger part of this matter is of a carbonaceous rather than of a nitrogenous nature. The practical bearing of this is that it indicates clearly that from the ordinary intermittent sand filter for the disposal of sewage, sand will, in most instances, eventually have to be removed, notwithstanding careful oversight and good operation of such filters.